

(19)



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Office européen des brevets



(11)

EP 0 998 076 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
03.05.2000 Bulletin 2000/18

(51) Int Cl.7: **H04L 12/26, H04L 12/24**

(21) Application number: **99308205.6**

(22) Date of filing: **18.10.1999**

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE**
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **30.10.1998 US 184101**

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(54) **Method for controlling a network element from a remote workstation**

(57) A method is provided for controlling a network element from a client at a remote work station connectable to the network, the network, element is registered

for attributes to be tracked, and attributes associated with the network element are polled only if the client requests the monitoring of the network element.

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Description**Background Of The Invention**

5 [0001] This invention relates, generally, to a method for controlling a network element and, more particularly, to a method for remotely controlling the network by communications through the network.

[0002] Network management systems in which network elements, or management agents, are remotely controlled from a remote, management work station by means of communications between the management work station and the managed network elements sent through the network are known. Such known network management systems
10 employ a special communication protocol for communications between the remote work station running a management program and an element management server that contains a management information base that defines the interface between the work station and the network elements.

[0003] Known systems such as (Hewlett Packard HP-OV NNM or DM, Sun Microsystems Solstice) present an interface where the client application must poll the network element when status is needed. In these systems, the polling
15 may not be coordinated and is replicated for each client, if each client is interested in the same attributes. Also, each of the clients receive the full results for each polling cycle (even if there was no change from the last cycle), increasing the bandwidth used to communicate between the client application and the network element, as well as creating additional processing overhead due to the replicated polling at the network element.

Summary Of The Invention

[0004] A method is provided for controlling a network element from a remote work station connectable to the network. The method provides for registering the network element for attributes to be tracked, and polling for attributes associated with the network element only if the client requests the monitoring of the network element. Changes in attributes are
25 reported when the client requests notification of changes in attributes. For attributes polled for a plurality of clients, changes in the attributes to one of the plurality of clients requesting notification of changes in the attributes are reported.

[0005] The method further provides for polling once for a plurality of clients that registers for the same attributes and reporting asynchronously changes in the attributes to a plurality of clients.

[0006] Another aspect of the invention provides for running an object oriented program at the remote work station to control an object associated with the controllable network element, translating interface operations generated by the work station during the running of the object oriented program to corresponding translated interface operations in an object oriented language associated with the object being controlled, and connecting the corresponding translated interface operations through the network to an object server to control the object associated with the network element in accordance with the translated interface operations.
30

[0007] These and other features and advantages of the present invention will become apparent from the following detailed description, the accompanying drawings and the appended claims.
35

Brief Description Of The Drawings

40 [0008] The foregoing advantageous features will be described in detail and other advantageous features of the invention will be made apparent from the detailed description of the preferred embodiment of the invention that is given with reference to the several figures of the drawings, in which:

45 Fig. 1 is a functional block diagram of the preferred embodiment of a management system using the preferred network element control method of the present invention;

Fig 2 is a functional block diagram of the preferred embodiment of the translating interface shown as a single functional block in Fig. 1;

50 Fig. 3 is a functional block diagram illustrating the interface with the controlled network element that is visible to object oriented client management application at the work station of Fig.1;

Fig. 4 is a table of a plurality of service objects that interact with the client management application run at the work station of Fig.1;
55

Fig. 5 is a table of a plurality of call back functions performed at the translating interface of Fig.2;

Fig. 6 is a table of the different fundamental data types capable of being translated by the translating interface of

Fig.2 in accordance with the invention.

Fig. 7 is a block diagram showing the relationship between client application-specific service object, and the internal service representative of managed object instances;

Fig. 8 is a table summarizing filter criteria that is valid for each event category; and

Fig. 9 is a table defining specific exceptions with an EMAPI exception code containing one of the listed values.

Detailed Description

[0009] This invention provides an application programming interface (API) and protocol that provides for efficient communication between a distributed client application and an element management server independent of the communication protocol to the network element. The Element Management Application Programming Interface (EMAPI) provides the following benefits over known management system. The invention has application in the management of a telecommunication network element. For more information regarding such a management of a telecommunication network element refer to commonly owned U. S. patent application serial number 09/088,463, entitled "Method for Computer Internet Remote Management of a Telecommunication Network Element" by William E. Barker, Lisa M. Connelly, Marvin A. Eggert, Michael P. Foley, Kenneth R. Macfarlane, Philip M. Parsons, Girish Rai, Jerome E. Rog, and Kurt A. Vangness, filed on May 31, 1998, the disclosure of which is hereby incorporated by reference.

- Efficient use over low bandwidth connections. Client applications register for network element information they wish to track and after an initial set of data only receive incremental updates (deltas) when there are changes.
- Centralized polling of attributes. Attributes are only polled if a client exists that has registered to monitor the attribute. If multiple clients register for the same attribute(s), the polling is not repeated for the clients-only a single polling cycle is performed.

[0010] The invention is used in an operations, administration and maintenance system 20 as shown in Fig. 1. The system 20 includes a PC or workstation 22, an element management server (EMS) 24, an interface in accordance with the invention 26, located between the workstation 22 and an object server 25. An application processor 28 is connected to the element management server 24.

[0011] The workstation 22 includes a web browser 30 which is the interface to the client and is a host for JAVA applets 32 and web browser HTML 35 which is a hypertext markup language.

[0012] The system 20 operates on a cluster computing environment, and leverages off-the-shelf technology to enable additional customers visible features, while extending to subsequent releases and other projects, with minimal increased cost. System 20 is provided through the web browser interface and a SNMP based element management platform.

[0013] A client executes applications via web pages at the workstation 22. The client makes requests for various views of the network status by making selections through the web browser 30. The web browser requests pages from the web server 28 which transmits HTML pages that contain instructions to load and run the appropriate JAVA applet 32. One the applet starts, it communicates with the object server 25 through the interface 26 to perform initialization and to request initial configuration and status information that is appropriate for the current requested view. The JAVA applet 32 then registers with the object server 25 for subsequent notifications of changes to configuration and status that it requires to keep the view up to date. The client may perform commands to request various maintenance operations on the network element 28. These commands are converted into appropriate requests through the interface 26 and perform operations on the object server 25. The commands are then translated into SNMP and are transmitted to the network element 28 through the SNMP library 33. Acknowledgements and command responses from the network element 28 are transmitted through the SNMP library 33, are converted to events by the object server 25 and transmitted to originating JAVA applet 32 through the use of callbacks defined by the interface 26.

[0014] In one embodiment of the invention, as shown in Fig. 3, client applications in JAVA applets 32 include an active alarm list browser, a system alarm survey and a network element detailed status display. Client applications communication with the web server 28 via the interface 26 in accordance with the invention, to the element manager through a distributed object request architecture such as CORBA. The interface 26 provides a constant interface to all managed objects in the network, and hides the implementation details associated with the element manager platform.

[0015] The interface 26 (EMAPI) is the definition of objects, attributes and operations that comprise the protocol used between client applications and the server to manage network elements. The EMAPI uses the industry standard CORBA to provide distribution of the objects and their operations and to allow for the implementation of the client and server

to be in different programming languages and on different computer architectures.

[0016] The client interface to the server and the managed object attributes is described in the interface 26 and managed object notation provides a consistent model of all managed objects in the network, hiding the implementation details associated with the element manager platform from client applications, thus clients do not need to know the underlying protocol to the network elements. Managed objects specific logic is encapsulated within the managed object instead of scattered throughout various applications thus simplifying client application development.

[0017] Each physical, selected non-physical and logical component in the network is modeled as a managed object, which the Server makes visible to distributed client applications through the facilities of the Common Object Request Broker Architecture (CORBA). EM clients need only be concerned about the attributes and operations defined for each application managed object, and not the details of network-level protocol and the server infrastructure required to support object services.

EMAPI Object Definition

[0018] Fig. 3 illustrates all of the interfaces visible to client applications which does not depict process or processor boundaries, which are made transparent by the client and server object request brokers (ORBs). Application services are provided through object interfaces formally defined in the CORBA Interface Definition Language (IDL). The IDL specification of the interfaces described in this document is provided in the Appendix A.

[0019] The service objects resident on the server with which client applications will interact are shown in Fig. 4.

[0020] Client applications which register for real-time status updates or notification of events, alarms or configuration changes must provide a reference to a local callback object which the server will use to propagate information asynchronously. The callback interfaces defined in the interface 26 are shown in Fig. 5. Classes which implement these interfaces must be defined and instantiated in client code.

Data Representation

[0021] There are several fundamental data types defined in the interface 26, which fall into one of the two categories shown in Fig. 6.

Session Management

[0022] Each EM client session is logically associated with a unique login-host combination. Multiple client applications may be associated with the same session, though only one need be registered for the session to be considered active. Session and application identifiers are assigned by the User Session Manager to track resources used by the client, and in future releases, to correlate client access permissions with operation requests. Applications may or may not cross process boundaries. For example, multiple instances of the EMS Command Line Interface (CLI) application registered with the same login and host name will share the same session id, but each process is associated with a different application id. In the EMS Graphical User Interface, all application frames execute in the same process space (albeit in different Threads), yet each frame is associated with a distinct application id. Note that each client application is required to independently register a periodic heartbeat to validate for the Server that its associated resources are still needed.

[0023] The UserSession service object provides the following interfaces:

- startApplication

This method must be invoked for each client application initialization.

- stopApplication

A client invokes this method to notify the Server that a target application is terminating, and its associated resources should be released.

- stop

This method may be used to deregister all applications associated with the same session identifier.

- heartbeat

[0024] This method must be invoked at least every UserSession::HeartbeatPeriod seconds to avoid a timeout condition which, when detected by a Server audit, will result in the release of all resources utilized by an application.

[0025] Refer to the description of interface UserSession in the attachment for additional details.

Managed Objects

[0026] A managed object (MO) is an abstract representation of a physical or logical resource which may be managed by the EMS, such as a network element, maintenance unit or data link. The EM Server will implement one application-specific service object for each type of physical or logical resource to be managed. Each of these service objects defines a set of attributes which identify managed object properties, as well as the operations which may be performed on a specified managed object instance. (The decision to provide access to instance information through a single "service object" stems from the fact that current ORB implementations become unstable when managing very large numbers of remote references.) Fig. 7 depicts the relationship between Client, application-specific service object, and the internal Server representation of managed object instances.

[0027] Each managed object service class is uniquely identified by a ClassCode. Each managed object instance is uniquely identified by an InstId. Any object instance in the system may be uniquely referenced by a managed object identifier (Oid), which is the combination of ClassCode and InstId.

[0028] Managed object status information is reported by a service object as a sequence of attribute code-value pairs. Each attribute value is defined as a union of all of the interface 26 fundamental data types described in Fig. 6.

[0029] Configuration information is reported as a sequence of ConfigData structures, which are defined to contain:

- network element instance id
- managed object instance id
- a managed object key list reported as a sequence of attribute-value pairs-- when length is greater than 0, the key list specifies the associated logical identifiers (LogicalIds)

[0030] Each managed object service class must implement the MO interface, which defines the following configuration and status services:

- viewConfig
A client uses this method to obtain the current EMS view of the managed object configuration for a specified network element instance. Note that the reserved instance identifier AnyInstance may be used to obtain configuration information for all network elements.
- notifyConfig
A client may also register for an initial view of managed object configuration information and notification of subsequent changes via callback. The initial view is returned with a notification type CONFIG_INIT. Subsequent changes are reported with type CONFIG_CREATE or CONFIG_DELETE.
- cancelNotify
A client uses this method to cancel registration for managed object configuration notifications associated with a specified client application.
- getPersistent
A client may use this method to retrieve the set of attribute codes (SeqAttrCode) identifying all "persistent" data maintained by this service object. Values for persistent attributes of each managed object instance are stored and kept current irrespective of any client requests.
- getAttrSpec
A client may use this method to retrieve the name and codes of all attributes defined for a target service class (currently used for debugging only).
- getKeySpec
A client may use this method to retrieve the set of codes (SeqAttrCode) identifying the attribute(s) which represents the logical identifier(s) of any instance of the target class.
- viewStatus
A client may invoke this method to obtain the EMS view of the current values for a specified set of persistent attributes for a specified managed object instance.

- getStatus

A client may use this method to register for a snapshot of current status information. This interface differs from the previous one in that the requested attribute list may specify any managed object attribute codes—not just those associated with persistent data, and the information is returned via client status callback (StatusCB).

- startUpdate

A client may also register for an initial view and notification of any updates to a list of selected attributes for a specified managed object instance. In this case, an initial view is reported via client callback with a notification type STATUS_INIT. Subsequent changes are reported with type STATUS_CHANGE. Note that managed object instance deletions are reported only through configuration change notification to avoid a potential flurry of client status callbacks when a network element is unequipped.

- stopUpdate

A client uses this method to cancel registration for managed object status updates associated with a specified client application.

- getInst

A client may use this method to obtain a managed object instance identifier for a specified network element instance id and managed object key list.

[0031] Note that each method requires a client session application identifier (SessionAppId) to validate user access. In the case of configuration or status change notification registration, this identifier is also used to keep track of the additional server resources utilized while the client application is active.

[0032] Refer to the description of interfaces MO, ConfigCB & StatusCB in the attachment for additional details.

Network Element Level Managed Objects

[0033] Each network-element level managed object must also implement the NEMO interface which defines additional network-element level configuration services:

viewNEconfig

[0034] A client may invoke this method to obtain the current EMS view of the network element configuration.

- notifyNEconfig

A client may also register for an initial view of network element-level managed object configuration information and notification of subsequent changes via callback. The initial view is returned with a notification type CONFIG_INIT. Subsequent changes are reported with type CONFIG_CREATE or CONFIG_DELETE.

- cancelNEnotify

A client application should use this method to cancel registration for network element managed object configuration updates.

- getNEinst

A client may invoke this method to retrieve the NEMO instance identifier of the network element associated with a specified logical id.

- getLogicalId

A client may invoke this method to retrieve the logical identifier of the network element associated with a specified NEMO instance id.

- getContainment

A client may invoke this method to obtain a sequence of containment information for the target NEMO, where each entry in the sequence contains the name, class code and CORBA reference to a contained service class object.

[0035] Note that each method requires a client session application identifier to validate user access. In the case of configuration change notification registration, this identifier is also used to keep track of the additional server resources

utilized while the client application is active.

[0036] Refer to the description of interfaces NEMO & NEconfigCB in the attachment for additional details.

Descriptive Entity Objects

[0037] Application objects of this type are defined to provide type and attribute information for abstract entities, such as data communicated between the EMS and network elements which are not part of a managed object description (e.g. SNMP trap definitions and command groups). Descriptive entity objects provide no implementation—they are defined in application-specific IDL and known by client applications at compile time.

Event Distributor

[0038] An event is reported as a combination of the following:

1. A header, which contains information of most general interest:

- Time of the event
- Event category defined to be one of the following:
 - * Alarm Set
 - * Alarm Clear
 - * Command Acknowledgment
 - * Command Response
 - * Configuration Change
 - * Informational Message
 - * Initialization
 - * State Change
 - Network element object identifier
 - Network element alarm level-meaningful only for alarm set
 - Maintenance unit object identifier (if applicable)
 - Maintenance unit alarm level-meaningful only for alarm set
 - A command identifier (CmdId) defined as a user session id & command sequence number-meaningful only for command acknowledgment & response

1. Event data defined as a sequence of structures which contain:

- A ClassCode of a managed object, network element or descriptive entity
- A sequence of attribute code-value pairs

[0039] Client applications may request a copy of the event stream, as processed by the event distributor, filtered on information specified in the event header. Filter wildcards are implemented with "out-of-band" values:

- Any Category

- Any Class
- Any Instance
- 5 • Any Alarm
- Any Cmd

[0040] The table in Fig. 8 summarizes which filter criteria are valid for each event category:

[0041] The event distributor processes filters by examining the specified category and AND'ing together valid criteria. Clients may simulate OR operations by registering multiple filters.

[0042] The EvtDist service object implements the following client interfaces:

- RegisterFilter
15 A client uses this method to register an event filter. A filter identifier is returned.
- CancelFilter
A client invokes this method to remove a specified event filter, using the filter id returned from the associated registration.

[0043] Note that each method requires a client session application identifier to validate user access.

[0044] Refer to the description of interfaces EvtDist & EventCB in the attachment for additional details.

Alarm Manager

[0045] Alarm information is reported as a sequence of AlarmData structures which contain:

- The ClassCode of a managed object which defines a network-element specific alarm record.
Note that in the first release of the EMS, only one network element active alarm table is defined (ApActiveAlarms).
- A sequence of alarm records, each of which contains an alarm instance identifier and sequence of attribute code-value pairs.
Client applications may request a copy of all active alarms filtered on any combination of the following:
 - Network element
 - Maintenance unit
 - 40 • Alarm level

[0046] Similar to the interfaces provided by the event distributor, out-of-band values may be used to represent wild-cards.

[0047] Since managed object instance information may not be available at the time an alarm is reported, the actual alarm filter criteria are specified in terms of logical identifiers. Logical ids are integer values which represent the logical numbers of devices and interfaces (e.g. AP 4). The correlation between logical ids and managed object instance identifiers is provided in the configuration information made available by each managed object service object, and through the utility method getInst. Refer to the section on Managed Objects for additional details.

[0048] The following AlarmManager client interfaces are written specifically for the Active Alarm List application:

- RequestAlarms
A client invokes this method to register a filter for active alarms.
- ChangeFilter
55 A client may invoke this method to change filter criteria.
- RefreshAlarms
A client may invoke this method to refresh the active alarm list.

- CancelAlarms

A client should invoke this method to de-register a filter.

[0049] All operations except for de-registration return all active alarms filtered on the specified criteria. Also, each of these methods requires a valid client session application identifier to validate user access, and to keep track of the additional server resources which may be utilized while each client is active.

[0050] The following AlarmManager interface may be used by any client application (e.g. CLI):

- opAlarm

Through client implementations of event callbacks used to process command acknowledgements and responses (the same EventCB reference may be used in both cases), this method returns either a list of all active alarms in the system or just those associated with a target network element.

[0051] Refer to the description of interfaces AlarmManager, AlarmCB & EventCB in the attachment for additional details.

Exceptions

[0052] Exceptions are used for consistent and structured error handling in both the EM Server and Client.

[0053] The CORBA specification defines many system exceptions: •

- BAD_PARAM
- INV_OBJREF
- NO_PERMISSION
- BAD_OPERATION
- OBJ_ADAPTER
- ♦♦♦

[0054] Refer to "The Common Object Request Broker Architecture and Specification" for an exhaustive list of mnemonics and the associated exception descriptions.

[0055] Vendor-specific object request broker exceptions are also defined (using the Minor identifier of the SystemException):

- NO_IT_DAEMON_PORT
- LICENCE_EXPIRED
- ♦♦♦

[0056] Currently, the EMS uses Iona's Orbix product. Refer to the "Orbix 2.3c Reference Guide" for an exhaustive list of mnemonics and the associated exception descriptions.

[0057] In most cases, exceptions will be treated as fatal errors by Client code resulting in application termination.

[0058] An interface 26-specific exception is also defined as an Exception Code containing one of the following values shown in Fig. 9.

APPENDIX A- Emapl.idl

```

5  #ifndef _EMAPI_IDL
    #define _EMAPI_IDL

    //
    // File: Emapl.idl
    //
10  // Description: CORBA IDL file for the Element Manager API. All client
    //      visible interfaces that are common to all applications of the
    EMS
    //      are described here.
    //
    //
15  // interfaces which are referenced before they are defined
    interface ConfigCB;
    interface StatusCB;
    interface NEconfigCB;
    interface EventCB;
20  interface AlarmCB;

    // some of the more commonly used ASN.1 standard types
    typedef boolean          Asn1Boolean;
    typedef long             Asn1Integer;
25  typedef unsigned long    Asn1UInteger;
    typedef sequence<octet> Asn1Octet;
    typedef unsigned long    Asn1Timeticks;
    typedef unsigned long    Asn1Gauge;
    typedef unsigned long    Asn1Counter;
30  typedef octet            Asn1IpAddress[4];
    typedef octet            Asn1Null;
    typedef sequence<unsigned long> Asn1Oid;

    // logical identifier--one or more attributes of this type may be
35  defined
    // for any managed object to provide a logical identity (e.g.
    application
    // processor number, RCS number)
    typedef Asn1Integer      LogicalId;
    typedef sequence<LogicalId> SeqLogicalId;
40

    // definition of an object identifier
    typedef long              ClassCode;
    typedef unsigned long     InstId;

45  struct Oid {
        ClassCode      classId;
        InstId         instId;
    };

50  // reserved class id
    const ClassCode      AnyClass      = -1;

    // reserved instance id's
    const InstId         NullInstance  = 0;
    const InstId         AnyInstance   = 1;
55  const InstId         MaxRsvdInst   = 1;

```

```

// instance id associated with singleton objects (e.g. System)--note
// that
// this is the first id normally assigned
5 const InstId      SingletonInst    = MaxRsvdInst + 1;

// reserved logical id
const LogicalId     AnyLogicalId     = -1;

// application identifier
10 typedef long       AppId;

// reserved application id's
const AppId         NullAppId        = -1;
const AppId         AnyAppId         = -2;

15 // application/session identifier
struct SessionAppId {
    InstId           session;
    AppId            app;
20 };

// maximum number of applications active per single user session
const short         MaxSessionApps   = 10;

// command identifier
25 typedef long       CmdSeqNo;

// reserved command sequence number
const CmdSeqNo      AnyCmd           = -1;
const CmdSeqNo      InvalidCmd       = -1;

30 struct CmdId {
    InstId           session;
    CmdSeqNo         seqNo;
};

// element manager base application programming interface exception
35 codes
enum EmapiExceptionCode {
    EM_INVALID_USER,
    EM_UNKNOWN_HOST,
    EM_TOO_MANY_USER_SESSIONS,
    EM_TOO_MANY_APPLICATIONS,
40 EM_INVALID_SESSION_ID,
    EM_INVALID_APP_ID,
    EM_INVALID_INST_ID,
    EM_INVALID_NE_ID,
    EM_INVALID_MO_ID,
45 EM_INVALID_ATTR_CODE,
    EM_NO_MATCHING_INST,
    EM_INVALID_FILTER,
    EM_INVALID_FILTER_ID,
    EM_NE_ISOLATED,
50 EM_INTERNAL_ERROR,
    EM_INVALID_OPERATION,
    EM_ACCESS_DENIED,
    EM_VERSION_MISMATCH,
    EM_LOST_RESOURCE,
55 EM_INVALID_KEY,
    EM_INVALID_CATEGORY

```

```

1;

// element manager exception
exception EapiException { EapiExceptionCode errCode; };

5
// Access permissions:
//     For now, permission is granted on a network element basis:
//         on any kind of access
//         on status information access
10 //         on maintenance operation access
//     The network element basis can be:
//         on any network element
//             Oid: (AnyClass,AnyInstance)
//         on any instance of a particular network element type
//             Oid: {<class>,AnyInstance}
15 //         on a specific instance of a particular network element
type
//             Oid: {<class>,<instance>}

// Kinds of Access (set to be manageable by using a bit map/mask):
20 typedef Asn1Integer     AccessType;

const     AccessType     AnyAccess = -1;
const     AccessType     NoAccess = 0;
const     AccessType     StatusAccess = 1;
const     AccessType     OperationAccess = 2;
25 //const AccessType     NextAccess = 4;
//const AccessType     AfterThat = 8
//const AccessType     AfterThat = 16
// ...and so on, in powers of 2

30 // AccessPermission structure:
//     accessible     TRUE or FALSE for this type of access
//     accessType     type of access
//     oid            network element involved in this type of
access

35 struct AccessPermission {
    boolean     accessible;
    AccessType  accessType;
    Oid         oid;
};

40 // Application registration results in the client's receiving a
sequence of
// AccessPermission blocks.

typedef sequence<AccessPermission>     SeqAccessPermission;

45 struct AccessPermissionList {
    SessionAppId     sessionAppId;
    SeqAccessPermission     seqAccessPermission;
};

50 // user session
interface UserSession {
    // Null Session
    const InstId     NullSession     = 0;

55

```

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```

// maximum number of sessions per system
const short      MaxUserSessions      = 32;

// heartbeat period in seconds (Applications should use this
value to
// time their heartbeats with the server.)
const long       HeartbeatPeriod      = 5;

// client application registration: must be called once per
// application.
//
// INPUTS:
//     applicationName: determined by client application
//     host: name of host on which client is running
//     user: login id
//     passwd: user's password
// RETURNS:
//     unique id for this session's application
//     plus a sequence of AccessPermission blocks
//     showing what is accessible from this application
// NOTE: The client's responsibility to delete the returned
pointer
//
// THROWS:
//     EM_TOO_MANY_SESSIONS
//     EM_TOO_MANY_APPLICATIONS
AccessPermissionList startApplication(
    in string host,
    in string user,
    in string passwd,
    in string applicationName)
    raises(EmapException);

// client deregistration -- entire session
//
// INPUT: a session application id
//
// THROWS:
//     EM_INVALID_SESSION_ID
void stop(in InstId sessionId) raises(EmapException);

// client deregistration -- single application
//
// INPUT: a session application id
//
// THROWS:
//     EM_INVALID_SESSION_ID
//     EM_INVALID_APPLICATION_ID
void stopApplication(in SessionAppId id)
    raises(EmapException);

// client heartbeat
//
// INPUT: session application id
//
// THROWS:
//     EM_INVALID_SESSION_ID
//     EM_INVALID_APP_ID
//     EM_INTERNAL_ERROR

```

```

void heartbeat(in SessionAppId id) raises (EapiException);
};

//
// Managed Object definition. The Managed Object (MO) describes
// definitions
// and operations that are common to all application specific managed
// objects in the system.
//
10 interface MO {
    // All attributes of an MO are identified by integer constant
    // codes called AttrCodes.
    typedef long                      AttrCode;
    const AttrCode                    NullAttrCode    = -1;

15
    //
    // The following attribute codes are reserved and are used
    // by the MO implementation. Clients should always use the
    // attribute codes found in the application specific managed
    // object definition (e.g. AppModule.idl) and not these.
20
    //
    const AttrCode                    moInstanceCode = 0;
    const AttrCode                    neInstanceCode = 1;
    const AttrCode                    LastReservedCode = 1;

25
    // clients register for updates by specifying a sequence of
    // attribute codes
    typedef sequence<AttrCode>        SeqAttrCode;

    // The attribute value is a discriminated union of scalars
    // All basic types currently supported by the EMS are
30 described
    // here.
    typedef long                      AttrType;
    const AttrType                    ValInstId      = 1;
    const AttrType                    ValAsn1Boolean = 2;
35 const AttrType                    ValAsn1Integer  = 3;
    const AttrType                    ValAsn1UInteger = 4;
    const AttrType                    ValAsn1Octet    = 5;
    const AttrType                    ValAsn1Timeticks = 6;
    const AttrType                    ValAsn1Gauge    = 7;
    const AttrType                    ValAsn1Counter  = 8;
40 const AttrType                    ValAsn1IpAddress = 9;
    const AttrType                    ValAsn1Null     = 10;
    const AttrType                    ValAsn1Oid      = 11;
    const AttrType                    ValAsn1LogicalId = 12;

45
    //
    // The following union defines all possible attribute types
    // in the EMS.
    //
    union AttrValue switch(AttrType) {
50         case ValInstId:                InstId                instId;
        case ValAsn1Boolean:            Asn1Boolean            asn1Boolean;
        case ValAsn1Integer:             Asn1Integer            asn1Integer;
        case ValAsn1UInteger:            Asn1UInteger            asn1UInteger;
        case ValAsn1Octet:               Asn1Octet              asn1Octet;
        case ValAsn1Timeticks:           Asn1Timeticks          asn1Timeticks;
55         case ValAsn1Gauge:             Asn1Gauge              asn1Gauge;
    }

```

```

        case ValAsn1Counter:      Asn1Counter      asn1Counter;
        case ValAsn1IpAddress:    Asn1IpAddress    asn1IpAddress;
        case ValAsn1Null:         Asn1Null         asn1Null;
        case ValAsn1Oid:          Asn1Oid          asn1Oid;
5      case ValLogicalId:         LogicalId         logicalId;
    };

    //
    // each set of updates on a managed object is delivered
    // as a sequence of attribute-value pairs (SeqAttrCodeValue).
10   //
    struct AttrCodeValue {
        AttrCode      code;
        AttrValue     value;
    };
15   typedef sequence<AttrCodeValue> SeqAttrCodeValue;

    //
    // The getAttrInfo method of the MO returns a sequence of
    // information that describes each available attribute.
20   //
    struct AttrInfo {
        AttrCode      code;
        AttrType      type;    // note: currently not
        Asn1Octet     name;
25   };

    typedef sequence<AttrInfo> SeqAttrInfo;

    //
    // Config update notifications (via the deliverConfig method
30   // ConfigCB) can take two forms.
    //      1) One or more managed object instances have been
    //      created.
    //      (CONFIG_CREATE).
35   //      2) One or more managed object instances have been
    //      deleted.
    //      (CONFIG_DELETE).
    //
    enum ConfigNotifyType {
40   CONFIG_CREATE,    // a new MO instance has been created
    CONFIG_DELETE     // an existing MO instance has been
    deleted.
    };

    //
45   // Status update notifications (via the deliverStatus method
    // StatusCB) can take two forms.
    //      1) An initial update (STATUS_INIT) that is returned
    //      either
    //      as a result of a getStatus or as the initial status
50   //      from
    //      a startUpdate request.
    //      2) An incremental update (STATUS_CHANGE) representing a
    //      change
55

```

```

//      to one or more of the attributes that the client
registered for.
//
5      enum StatusNotifyType {
          STATUS_INIT,      // represents initial status update of
all                                     // requested attributes (e.g.
startUpdate)
10      STATUS_CHANGE      // represents an incremental status
update                                     // (contains only attributes that have
                                                // changed).
    };

15    //
    // each config update notification will be delivered as a
sequence of:
    //      network element instance id
    //      managed object key list (sequence of attr-
value pairs)
20    //      managed object instance id
    struct ConfigData {
        InstId              neInst;
        SeqAttrCodeValue    keyList;
        InstId              moInst;
25    };

    typedef sequence<ConfigData>    SeqConfigData;

    //
30    // viewConfig() - obtain EMS view of the current managed
object
    //      configuration for a specified network element
instance.
    //      The special value AnyInstance may be used to obtain
    //      configuration information for all network elements
35    known
    //      to the EMS.
    // INPUTS:
    //      sessionAppId - client session/application identifier.
This is
40    //      used to validate client permission to
perform
    //      the operation.
    //      neInst      - specific NE instance identifier, or
AnyInstance
    //      to get config for all NE instances.
45    // RETURNS:
    //      A sequence of configuration information (sequence
length
    //      is proportional to the number of configured MO
instances).
    //      CALLER MUST DELETE RETURNED MEMORY.
50    //
    // THROWS:
    //      EM_INVALID_SESSION_ID
    //      EM_INVALID_APP_ID
    //      EM_INVALID_INST_ID
55    //

```



```

SeqConfigData viewConfig(in SessionAppId    sessionAppId,
                        in InstId          neInst)
                        raises(EmapiException);

5      //
      // notifyConfig() - Client registration for managed object
      // configuration information for specified network
element //
10 notifications // instance (or the AnyInstance to register for
      // on all network element instances). The current
snapshot // of configuration is returned (like viewConfig) and all
      // subsequent configuration changes result in an
15 invocation of // the specified callback.
      //
      // INPUTS:
      // sessionAppId - client session/application identifier.
This is //
20 // used to validate client permission to
perform // the operation.
      // neInst - specific NE instance identifier, or
AnyInstance // to get config for all NE instances.
25 // callback - client callback (implements the
ConfigCB // interface) that will be invoked for
all // config changes.
30 // RETURNS:
      // A sequence of configuration information (sequence
length // is proportional to the number of configured MO
instances). //
35 // CALLER MUST DELETE RETURNED MEMORY.
      //
      // THROWS:
      // EM_INVALID_SESSION_ID
      // EM_INVALID_APP_ID
      // EM_INVALID_INST_ID
40 //
SeqConfigData notifyConfig(in SessionAppId    sessionAppId,
                        in InstId          neInst,
                        in ConfigCB        callback)
                        raises(EmapiException);

45 //
-// cancelNotify() - Cancel all requests for configuration
change //
      // notifications associated with the specified client
application. //
50 //
      // INPUTS:
      // sessionAppId - client session/application identifier.
This is //
55 // used to validate client permission to
perform

```

```

// the operation.
// RETURNS:
// void
5 //
// THROWS:
// EM_INVALID_SESSION_ID
// EM_INVALID_APP_ID
//
10 void cancelNotify(in SessionAppId sessionAppId)
raises(EmapiException);

//
// getPersistent() - Obtain the attribute codes for all
persistent
15 // attributes maintained by this managed object.
Persistent
// attributes are those that the EMS keeps the current
value // regardless of client registrations. Other attributes
are // polled for only when a client makes a request or
20 registers // for update notifications.
// INPUTS:
// sessionAppId - client session/application identifier.
25 This is //
perform // used to validate client permission to
// the operation.
// RETURNS:
// a sequence of attribute codes representing the
30 persistent // attributes.
// CALLER MUST DELETE RETURNED MEMORY.
//
// THROWS:
35 // EM_INVALID_SESSION_ID
// EM_INVALID_APP_ID
//
SeqAttrCode getPersistent(in SessionAppId sessionAppId)
raises(EmapiException);

40 //
// getAttrSpec() - Return identification of attributes that
are // defined for the specific managed object instance. A
sequence // containing the attribute name (an OCTET representing
45 the // ASCII string name) and the associated attribute code
// is returned.
//
// INPUTS:
50 // sessionAppId - client session/application identifier.
This is //
perform // used to validate client permission to
// the operation.
55 // RETURNS:

```

```

//      A sequence of attribute info representing the
//      attribute names and codes.
//      CALLER MUST DELETE RETURNED MEMORY.
//
5      // THROWS:
//      EM_INVALID_SESSION_ID
//      EM_INVALID_APP_ID
//
10      SeqAttrInfo getAttrSpec(in SessionAppId sessionAppId)
//                               raises(EapiException);

//
//      getKeySpec() - Return identification of key attributes. A
sequence //      of attribute codes representing the keys is returned.
15 Note //      that the sequence will be in the order defined in the
//      MOview.
//
//      INPUTS:
20 //      sessionAppId - client session/application identifier.
This is //
perform //      used to validate client permission to
//      the operation.
//      RETURNS:
25 //      A sequence of attribute codes.
//      CALLER MUST DELETE RETURNED MEMORY.
//
//      THROWS:
//      EM_INVALID_SESSION_ID
30 //      EM_INVALID_APP_ID
//
SeqAttrCode      getKeySpec(in SessionAppId sessionAppId)
//                               raises(EapiException);

//
35 //      viewStatus() - obtain EMS "view" of the values of the
specified //      persistent attributes.
//      INPUTS:
//      sessionAppId - client session/application identifier.
40 This is //
perform //      used to validate client permission to
//      the operation.
//      instId '      - MO instance. This specifies the MO
whose //
45 //      attributes are to be examined.
-//      attrList      - sequence of attribute codes that are to
be //
//      viewed.
//      RETURNS:
50 //      a sequence of attribute code/value pairs representing
the //
//      current view of the attribute values.
//      CALLER MUST DELETE RETURNED MEMORY.
//
55

```

```

// THROWS:
//     EM_INVALID_SESSION_ID
//     EM_INVALID_APP_ID
5 //     EM_INVALID_INST_ID
//     EM_INVALID_MO_ID
//     EM_INVALID_ATTR_CODE
//
SeqAttrCodeValue viewStatus(in SessionAppId      sessionAppId,
10                          in InstId            instId,
                          in SeqAttrCode        attrList)
                          raises (EmapiException);

//
// getStatus() - request for a snapshot of current status
15 //     information. This differs from viewStatus in that
attrList //     may specify any managed object attribute codes, and
the //     information is returned via client callback. The
callback is //     used because the request may require a get request to
20 the //     network element.
//
// INPUTS:
25 //     sessionAppId - client session/application identifier.
This is //
perform //     * used to validate client permission to
//     the operation.
//     instId        - MO instance. This specifies the MO
30 //     attrList     - sequence of attribute codes that are to
be //     retrieved.
// RETURNS:
35 //     void
//
// THROWS:
//     EM_INVALID_SESSION_ID
//     EM_INVALID_APP_ID
//     EM_INVALID_INST_ID
40 //     EM_INVALID_MO_ID
//     EM_INVALID_ATTR_CODE
//
void getStatus(in SessionAppId sessionAppId,
              in InstId        instId,
45              in SeqAttrCode  attrList,
              in StatusCB      callback)
              raises (EmapiException);

//
// startUpdate() - client registration for notifications of
50 //     any updates to the values of the specified set of
attributes.
//     An initial snapshot of all requested attributes is
//     delivered first (type=STATUS_INIT) followed by
notifications
55

```

```

//      of only those attributes that have changed
(type=STATUS_CHANGE)
//      Note that this method may result in polling to the
5 network
//      element, but only if the attributes are not persistent
and
//      no other clients have issued a startUpdate for the
//      attributes (only a single poll is used for all
10 //      registered
//      clients).
// INPUTS:
//      sessionAppId - client session/application identifier.
This is
15 //      used to validate client permission to
perform
//      the operation.
//      instId      - MO instance. This specifies the MO
//                  whose attributes are to be examined.
//      attrList    - sequence of attribute codes that are to
20 be
//                  monitored.
// RETURNS:
//      void
//
25 // THROWS:
//      EM_INVALID_SESSION_ID
//      EM_INVALID_APP_ID
//      EM_INVALID_INST_ID
//      EM_INVALID_MO_ID
//      EM_INVALID_ATTR_CODE
30 //
void startUpdate(in SessionAppId sessionAppId,
                in InstId      instId,
                in SeqAttrCode attrList,
                in StatusCB    callback)
35 raises(EmapiException);

//
// stopUpdate() - client deregistration for status updates.
Cancel
40 //      all monitoring activity associated with the specified
client
//      application. Note that the client may have issued a
number
//      of startUpdate requests for different instances, but
this
45 //      single call to stopUpdate will cancel all of those
requests.
//
// INPUTS:
//      sessionAppId - client session/application identifier.
This is
50 //      used to validate client permission to
perform
//      the operation.
// RETURNS:
//      void
55 //

```

```

// THROWS:
//     EM_INVALID_SESSION_ID
//     EM_INVALID_APP_ID
//
5      void stopUpdate(in SessionAppId sessionAppId)
raises(EmapiException);
//
// getInst() - return the instance identifier associated with
the
10     // specified keys.
//
// INPUTS:
//     sessionAppId - client session/application identifier.
This is
15     // used to validate client permission to
perform
// the operation.
//     neInst - the network element instance identifier
of the
// NE that contains the managed object
20 instance
// specified by the keys.
// RETURNS:
//     the InstId of the managed object, or NullInstance if
not found.
25     //
// THROWS:
//     EM_INVALID_SESSION_ID
//     EM_INVALID_APP_ID
//     EM_INVALID_INST_ID
//
30     InstId getInst(in SessionAppId sessionAppId,
                    in InstId neInst,
                    in SeqAttrCodeValue keyValues)
                    raises(EmapiException);
};

35 //
// client callback for managed object configuration reporting
//
interface ConfigCB {
40     oneway void deliverConfig(in ClassCode classId,
                                in MO::ConfigNotifyType type,
                                in MO::SeqConfigData config);
};

//
45 // client callback for managed object status reporting
//
interface StatusCB {
    oneway void deliverStatus(in Oid oid,
                                in MO::StatusNotifyType type,
                                in MO::SeqAttrCodeValue
50 attrValList);
};

// network element level managed object
interface NEMO : MO {
55

```

```

// attribute code reserved for boolean network element
// isolation indication.
const AttrCode IsolatedCode = 1;

5      //
// each network level configuration update notification is
delivered // as a sequence of:
//          network element instance id
10      //          network element logical id
struct NEconfigData {
    InstId      instId;
    LogicalId    logicalId;
};
15      typedef sequence<NEconfigData> SeqNEconfigData;

//
// Sequence of containment information describing all
// contained managed objects.
//
20      struct ContainmentInfo {
    ClassCode    classCode;
    MO            moRef;
    Asn1Octet    name;
};

25      typedef sequence<ContainmentInfo> SeqContainmentInfo;

//
// viewNEconfig() - obtain EMS view of current network element
// configuration
30      //
// INPUTS:
//      sessionAppId - client session/application identifier.
This is //
perform //          used to validate client permission to
35      //          the operation.
// RETURNS:
//      Sequence of network element configuration information.
//      CALLER MUST DELETE RETURNED MEMORY.
//
40      // THROWS:
//      EM_INVALID_SESSION_ID
//      EM_INVALID_APP_ID
//
SeqNEconfigData viewNEconfig(in SessionAppId sessionAppId)
45      raises (EmapiException);

//
// notifyNEconfig() - client registration for network level
// managed object configuration. An initial snapshot of
// the network element level configuration is returned.
50      // All subsequent changes to the network element
// configuration are delivered via the specified callback.
//
// INPUTS:
//      sessionAppId - client session/application identifier.
55      This is

```

```

//          used to validate client permission to
perform
//          the operation.
5 //          callback      - callback object that is to receive
delivery
//          of changes to configuration.
// RETURNS:
//          Sequence of network element configuration information.
10 //          CALLER MUST DELETE RETURNED MEMORY.
//
// THROWS:
//          EM_INVALID_SESSION_ID
//          EM_INVALID_APP_ID
//
15 SeqNEconfigData notifyNEconfig(in SessionAppId sessionAppId,
                                in NEconfigCB callback)
                                raises(EmapiException);

//
// cancelNEnotify() - cancel request for NE configuration
20 // change notifications
//
// INPUTS:
//          sessionAppId - client session/application identifier.
This is
25 //          used to validate client permission to
perform
//          the operation.
// RETURNS:
//          void
30 //
// THROWS:
//          EM_INVALID_SESSION_ID
//          EM_INVALID_APP_ID
//
void cancelNEnotify(in SessionAppId sessionAppId)
35 //          raises(EmapiException);

//
// getNEInst() - return the network element instance
identifier
//          associated with the specified NE logical identifier.
40 //
// INPUTS:
//          sessionAppId - client session/application identifier.
This is
//          used to validate client permission to
45 perform
//          the operation.
//          logicalId      - the logical identifier (integer) of
//                          the network element.
// RETURNS:
//          the InstId of the network element instance, or
50 NullInstance
//          if not found.
//
// THROWS:
//          EM_INVALID_SESSION_ID
55 //          EM_INVALID_APP_ID

```



```

//
InstId getNEInst(in SessionAppId      sessionAppId,
                 in LogicalId         logicalId)
                 raises(EmapiException);
5

//
// getLogicalId() - return the NE logical identifier
//                  associated with the specified instance identifier.
//
10 // INPUTS:
//     neInst      - the instance identifier of the network
element.
//
// RETURNS:
//     the logical identifier of the network element
15 instance,
//     or 0 if not found.
//
Asn1Integer getLogicalId(in InstId neInst);

20 //
// getContainment() - return sequence with containment
information
//     for this network element. The sequence returned
contains
//     the name, class code and a pointer to the associated
25 service
//     class object.
//
// INPUTS:
//     sessionAppId - client session/application identifier.
30 This is
//
//     used to validate client permission to
perform
//
//     the operation.
// RETURNS:
//     a sequence of containment information describing the
35 contained
//     managed objects.
//     CALLER MUST DELETE RETURNED MEMORY.
//
// THROWS:
//     EM_INVALID_SESSION_ID
40 //     EM_INVALID_APP_ID
//
SeqContainmentInfo getContainment(in SessionAppId
sessionAppId)
45
                                     raises(EmapiException);

);

// client callback for network element level managed object
configuration
// reporting
50 interface NEconfigCB {
    oneway void deliverNEconfig(in ClassCode      classId,
                                in NEMO::ConfigNotifyType type,
                                in NEMO::SeqNEconfigData config);
55 };

```

```

// typedefs for acknowledgement value & alarm level
typedef Asn1Integer      AckValue;
5 typedef Asn1Integer      AlarmLevel;

// no alarm filtering conjunctions are permitted, but we do allow a
// single
// filter to extract all alarmed notifications by defining an "out-of-
// band"
10 // alarm level
const AlarmLevel      AnyAlarm      = -1;

// typedef for event data structure--note that instance information
// may no
15 // longer be valid when an event is processed, so key information
// should
// always be available in the attribute-value list
struct EventData {
    ClassCode          classCode;
    MO::SeqAttrCodeValue seqVal;
20 };
typedef sequence<EventData>      SeqEventData;

// event distributor interface description
interface EvtDist {
25     // time of event as reported by EMS
    typedef long          EventTime;

    // categories of events
    enum Category {
30         ANY_EVENT,
        ALARM_CLEAR,
        ALARM_SET,
        CMD_ACK,
        CMD_RESP,
        CONFIG_CHANGE,
35         INFO_MSG,
        INIT_MSG,
        STATE_CHANGE,
        NUM_CATEGORIES
    };

40     // event header (not all members valid for all categories)
    struct Header {
        EventTime      eventTime;
        Category        category;
        Oid            networkElemId;
45         AlarmLevel    networkElemAlm;
        Oid            maintUnitId;
        AlarmLevel      maintUnitIdAlm;
        CmdId          cmdId;
    };

50     // event filter (not all members valid for all categories)
    struct Filter {
        Category        category;
        Oid            networkElemId;
        AlarmLevel      networkElemAlm;
55         Oid            maintUnitId;
    };

```

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```

AlarmLevel      maintUnitIdAlm;
CmdId           cmdId;
};

5 // cookie for client registration/deregistration
typedef long      FilterId;

// client registration for events
//
10 // INPUTS:
//     id:      SesionAppId associated with the filter
//     filter:   EvtDist::Filter that specifies filter
//               criteria
//     callback: EventCB that defines deliverEvent()
//               operation that will be called when an
15 //               incoming event matches the filter
// RETURNS:
//     unique FilterId for this filter
//
// THROWS:
20 //     EM_INVALID_SESSION_ID
//     EM_INVALID_APP_ID
//     EM_INVALID_CATEGORY
FilterId registerFilter(in SessionAppId id,
                       in Filter      filter,
25 //     in EventCB      callback)
                       raises(EmapiException);

// client filter deregistration
//
// INPUTS:
30 //     id:      SesionAppId associated with the filter
//               to be cancelled
//     filterId: FilterId of the filter to be cancelled
//
// THROWS:
35 //     EM_INVALID_SESSION_ID
//     EM_INVALID_APP_ID
//     EM_INVALID_FILTER_ID
void cancelFilter(in SessionAppId id,
                 in FilterId      filterId)
                 raises(EmapiException);
40 };

// client callback for event notification
interface EventCB {

45 // deliverEvent() is called by event distribution
// software whenever an incoming event matches
// a registered filter.
//
// INPUTS:
50 //     header: EvtDist::Header associated with the
//               incoming event
//     data:    SeqEventData (sequence of event data)
//               associated with the incoming
//               event
//
55 oneway void deliverEvent(in EvtDist::Header header,

```

```

                                in SeqEventData      data);

    // This empty operation is called during event filter
    // auditing to determine whether or not the associated
5    // session/application is still active.  If it has
    // terminated, a CORBA::SystemException will be thrown
    // and subsequently caught, indicating that the associated
    // filter should be removed from the filter queue.

10    oneway void check();
};

// typedefs for alarm data structures
struct AlarmRecord {
    InstId          instId;          // unique per alarm
15    definition MO::SeqAttrCodeValue attrValList;
};
typedef sequence<AlarmRecord> SeqAlarmRecord;

20    struct AlarmData {
        ClassCode          alarmDef;
        SeqAlarmRecord      alarmRecords;
    };
    typedef sequence<AlarmData> SeqAlarmData;

25    // alarm notification type
    enum AlarmNotifyType { ALARM_SET, ALARM_CLEAR };

    // active alarm manager interface description
    interface AlarmManager {
30        // active alarm filter--note that logical ids are specified
        since
            // instance information may not be available at the time
            alarms are
                // reported
35                struct AlarmFilter {
                    ClassCode          alarmDef;
                    LogicalId          networkElemId;
                    ClassCode          maintUnitClass;
                    SeqLogicalId       maintUnitId;
                    AlarmLevel         alarmLevel;
40                };

        // client registration for active alarms--both initial data &
        update
            // notifications (note that only one alarm filter can be
            registered
45            // with the alarm manager by each client application)
            SeqAlarmData requestAlarms(in SessionAppId      sessionAppId,
                                        in AlarmFilter        filter,
                                        in AlarmCB             callback)
                                        raises(EmapiException);

50            // request to change filter criteria (note that only one alarm
            filter
                // can be registered with the alarm manager by each client
                application)
55            SeqAlarmData changeFilter(in SessionAppId      sessionAppId,

```

```

                                in AlarmFilter      filter)
                                raises (EmapException);

5      // request to refresh alarm list--returns snapshot of current
alarms
      // (note that only one alarm filter can be registered with the
alarm
      // manager by each client application)
      SeqAlarmData refreshAlarms(in SessionAppId sessionAppId)
10      raises (EmapException);

      // client deregistration--cancel alarm set & clear forwarding
to the
      // specified client application (note that only one alarm
15      filter can
      // be registered with the alarm manager by each client
application)
      void cancelAlarms(in SessionAppId sessionAppId)
      raises (EmapException);
      // request for a list of all alarms in the entire system or
20      associated
      // with the indicated network element--supports the EMS
version of the
      // "OP:ALARM" technician command
      CmdSeqNo opAlarm(in SessionAppId      sessionAppId,
25      in ClassCode      alarmDef,
      in LogicalId      networkElemId,
      in EventCB      ackCB,
      in EventCB      cmdRespCB)
      raises (EmapException);

30      };

      // client callback for active alarm notification
      interface AlarmCB {
          oneway void deliverAlarms(in AlarmNotifyType      type,
35      in AlarmData      data);
      };

      // active alarms service object interface, derived from managed object
      // interface--note that no filtering of active alarms can be specified
      interface ActiveAlarms : MO {
          // system client (e.g., Active Alarm Manager) registration for
40      // active alarms--both initial data and update notifications
      SeqAlarmRecord getAlarms(in SessionAppId      sessionAppId,
      in AlarmCB      callback)
      raises (EmapException);

45      // system client (e.g., Active Alarm Manager) deregistration--
      // cancel active alarms update notifications
      void cancelAlarms(in SessionAppId sessionAppId)
      raises (EmapException);
      };

50      #endif // _EMAPI_IDL

      // EOF //

```

APPENDIX B-GLOSSARY

| | |
|---------------------------|--|
| Alarm | The description of an alarmed notification. |
| Attribute | A property of a managed object (e.g. alarm state). |
| Attribute Code | An integer value which uniquely identifies an attribute of a given managed object. |
| Class Code | An integer value which uniquely identifies a managed object class. |
| Configuration Information | Generic term which has one of two meanings depending on its context: With respect to a managed object class, this term applies to the identification of all instances of the class, either for a specific network element or for all network elements in the system. With respect to a managed object instance, this term may apply to one or more attributes which are associated with database values, such as the primary/alternate role of a duplex component. |
| CORBA | Common Object Request Broker Architecture |
| EMAPI | Element Management Application Programming Interface |
| EMS | Element Management System |
| Event | The description of a spontaneous occurrence, such as alarm notification, command acknowledgment or configuration change. |
| Instance Identifier | An integer value which uniquely identifies an instance of a given managed object. |
| Interface Operation | Generic term for distributed service request. The target method may be defined in the Element Management Application Programming Interface (e.g. status registration) or in an application-specific derivation of a managed object (e.g. command execution). |
| Logical Identifier | An integer value which represents the logical number of a device or interface (e.g. AP 4). Note that there is no direct correlation between a logical id and instance id. |
| Managed Object | An abstract representation of a physical or logical resource which may be managed by the EMS (e.g. network element, maintenance unit, data link). |
| ORB | Object Request Broker |
| Object Identifier | The combination of managed object class code and instance identifier which |

uniquely identifies any managed object instance in the system.

| | | |
|----|----------------------|---|
| 5 | Persistent Attribute | Information stored and kept current irrespective of any client request (e.g. maintenance state). |
| | Service Object | Any EM Server object which provides services to client applications. |
| 10 | Session | Each client must establish a session at initialization--for which a unique session identifier is assigned--that will be used to validate access permissions, to correlate client requests and to keep track of Server resources utilized in behalf of any applications associated with the session. |
| 15 | Status Information | Current attribute values for a managed object instance. |

Claims

- 20
1. In a network having a controllable network element, a method for controlling the network element from a remote work station connectable to the network, comprising the steps of:

25

registering the network element for attributes to be tracked; and

polling for attributes associated with the network element only if the client requests the monitoring of the network element.
 2. The method of claim 1 wherein the polling is performed by the server.
 3. The method of claim 1 including the step of reporting changes in attributes when the client requests notification of changes in attributes.
 4. The method of claim 1, including the steps of

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polling for the attributes for a plurality of clients, and

reporting changes in the attributes to one of the plurality of clients requesting notification of changes in the attributes.

40
 5. The method of claim 4 wherein the step of polling includes the step of polling once for a plurality of clients that registers for the same attributes.
 6. The method of claim 5 including reporting asynchronously changes in the attributes to a plurality of clients.
 7. The method of claim 1 wherein the step of polling is performed in a single polling cycle when multiple clients have registered for the same attributes.
 8. The method of claim 7 including the steps of

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running an object oriented program at the remote work station to control an object associated with the controllable network element;

translating interface operations generated by the work station during the running of the object oriented program to corresponding translated interface operations in an object oriented language associated with the object being controlled; and

55

connecting the corresponding translated interface operations through the network to an object server to control

the object associated with the network element in accordance with the translated interface operations.

9. The method of claim 8 in which step of translating includes the steps of

5 automatically determining which of a plurality of different object oriented languages is the object oriented language of the object being controlled, and

generating translated interface operations corresponding to the interface operations from the remote workstation to the object server in accordance with the language of the object being controlled as has been automatically determined.

10. The method of claim 8 in which the object oriented program run at the remote work station is a JAVA program.

11. The method of claim 8 in which the network element is located at a node of the network and the step of translating includes the step of

receiving the interface operations through a communication link of the network at a node separate from the node of the network element,

20 translating the interface operation through the network communication link into the corresponding translated interface operations by converting the received interface operations into IPC and TCP/IP requests.

12. The method of claim 11 in which the step of connecting includes the step of transmitting the IPC and TCP/IP requests to the object server.

13. The method of claim 12 in which the step of connecting includes the step of generating the IPC and TCP/IP request through a web-based GUI.

14. The method of claim 8 in which the object server responds to the translated object requests by

30 gathering information concerning the network element, and conveying the information concerning the network node that has been gathered to the remote work station by at least by one of the ways of

35 dynamically generating a web-page visual display associated with the network element being controlled for interfacing with the remote work station to display the gathered information.

15. The method of claim 14 in which the step of gathering includes the step of gathering network element information concerning at least one of the items of network element information of

40 a list of all active alarms,

a summary of system alarms, and

45 a detailed indication of the status of the network element.

16. The method of claim 15 in which the step of gathering includes the step of selectively gathering all of the items of information.

17. The method of claim 8 in which the step of translating includes the step of communication with the object server through a distributed object request architecture to provide a consistent interface to the managed object that hides implementation details associated with the object manager.

18. The method of claim 17 in which the distributed object request architecture is CORBA architecture.

19. The method of claim 8 in which the CORBA architecture functions as an IPC for functions residing on the object server to eliminate the need for platform specific language for the object oriented program at the remote station.

20. The method of claim 8 in which the CORBA architecture functions as an IPC for functions residing on the object

server to provide for distribution of functionality to multiple work station processors.

21. The method of claim 8 in which communication between the network element and the object server is through use of a network management protocol.

22. The method of claim 1 wherein the network management protocol is the simple network management protocol.

23. The method of claim 21 including the step of obtaining system status associated with the network element by polling and auditing pursuant to the simple network management protocol.

24. The method of claim 21 including the step of providing real-time notification of alarm conditions at the network element through the use of network management protocol event manager.

25. The method of claim 21 including the step of providing command and control signals to the network element through use of simple network management protocol set operation.

26. The method of claim 8 in which

the object server is part of an element management server that also includes a web server, and including the step of

displaying command and alarm output information from the network element as a web browser-based display through use of the web server.

27. The method of claim 26 in which

the element management server also includes an executive control processor, and including the step of

sending the command and alarm output information from the network element that is displayed through use of the web server to the executive control processor.

28. The method of claim 12 including the steps of

storing network element information concerning the network at the element management server, and

selectively providing the stored network element information to a plurality of different work stations.

29. The method of claim 8 including the step of sending from the network element event and alarm notifications to the object server through use of a network management protocol.

30. The method of claim 29 including the step of issuing commands from the network element to obtain input information from the work station running the object oriented program to the object server through the use of the network management protocol.

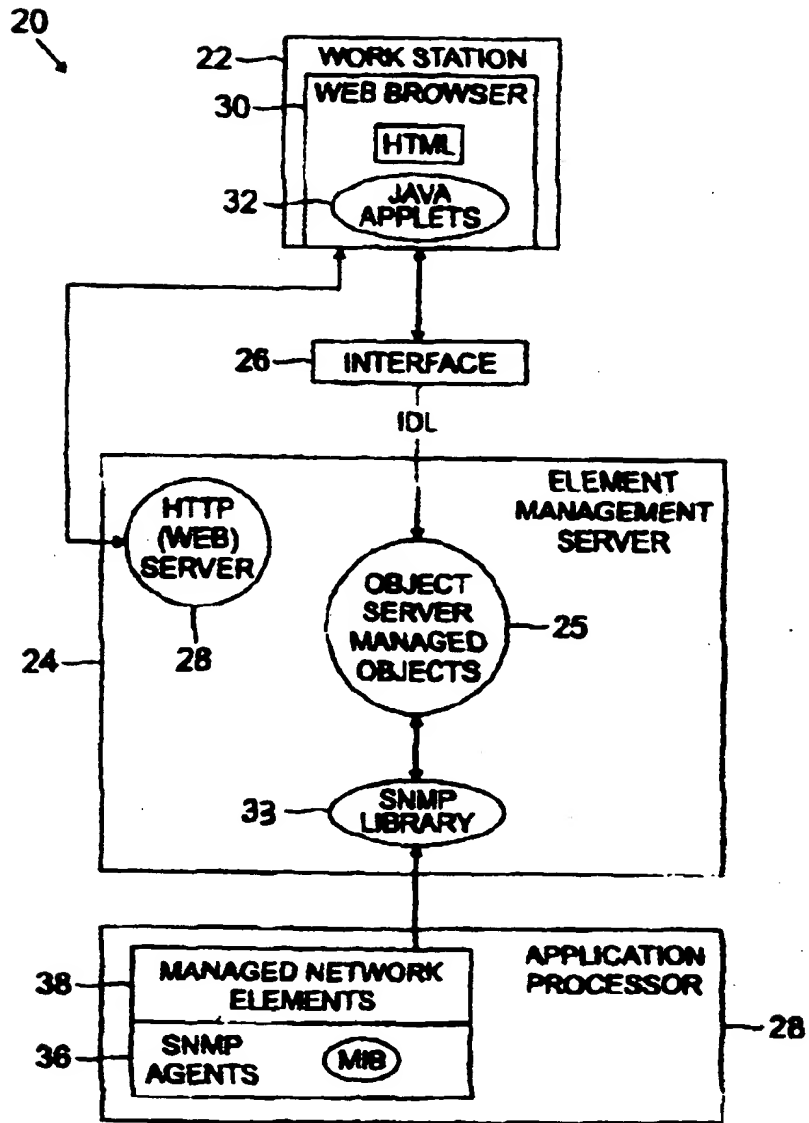


FIG. 1

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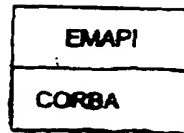


FIG. 2

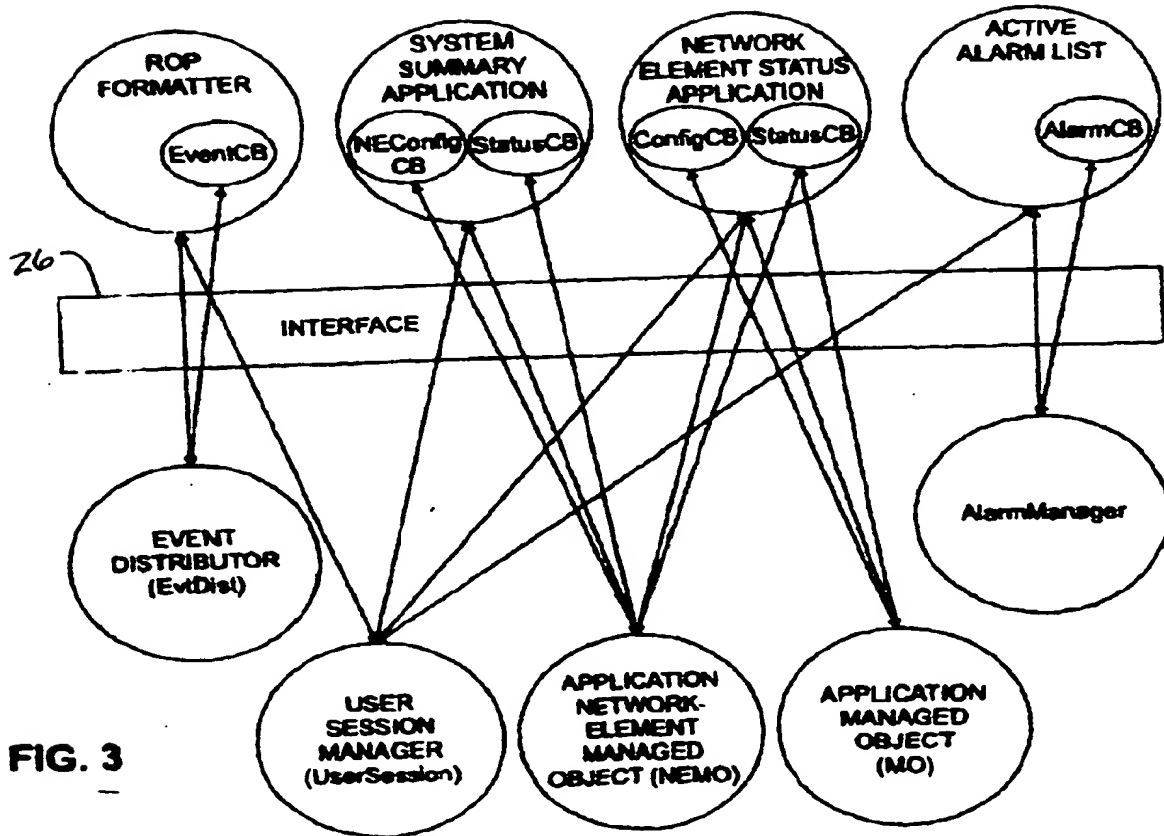


FIG. 3

| | |
|---|---|
| User Session Manager (UserSession) | In its current form, the primary function of the user session manager is to maintain a list of active client sessions and applications. In subsequent releases, this service object will provide user access security on a network-element and operation basis. Refer to the section on Session Management for a discussion of the interfaces provided by UserSession. |
| Managed Object (MO) | For each physical or logical resource which must be managed by the EMS, an abstract representation will be defined which identifies attributes and operations associated with the resource. Each application-specific managed object implemented on the Server must provide the same Client interfaces for retrieving configuration information, attribute values, and registration for notification of changes. Refer to the section on Managed Objects for further details. |
| Network-Element Level Managed Object (NEMO) | Each application-specific NEMO implemented on the Server must provide additional interfaces above those provided by the standard managed object to support network-element level configuration queries. Refer to the section on Network Element Level Managed Objects for further details. |
| Event Distributor (EvtDist) | The event distributor propagates events either received or generated at the Server to clients which register filters specifying event filter criteria. Refer to the section on the Event Distributor for the definition of an event and event filter, and a discussion of the Client interfaces provided by EvtDist. |
| Alarm Manager (AlarmManager) | The primary utility of the AlarmManager is realized through a single client application called the AlarmList. (Note that there may be more than one instance of the AlarmList application active at any one time). Alarm filters may be registered which filter alarm information based on network element, managed object or alarm level. The AlarmManager returns an initial view of all active alarms matching the specified criteria, and provides notification of changes resulting from subsequent alarm SET or CLEAR events. Refer to the section on the Alarm Manager for the definition of an alarm and alarm filter, and a detailed discussion of the Client interfaces provided by the AlarmManager. |

FIG. 4

| | |
|--|--|
| MANAGED OBJECT CONFIGURATION CALLBACK (ConfigCb) | A ConfigCb OBJECT MUST IMPLEMENT A deliverConfig() METHOD FOR NOTIFICATION OF MANAGED OBJECT CONFIGURATION CHANGES. REFER TO THE SECTION ON MANAGED OBJECTS FOR DETAILS ON THE FORMAT OF REPORTED CONFIGURATION DATA. |
| MANAGED OBJECT STATUS CALLBACK (StatusCb) | A StatusCb OBJECT MUST IMPLEMENT A deliverStatus() METHOD FOR NOTIFICATION OF MANAGED OBJECT ATTRIBUTE VALUE CHANGES. REFER TO THE SECTION ON MANAGED OBJECTS FOR DETAILS ON THE FORMAT OF REPORTED STATUS DATA. |
| NETWORK-ELEMENT LEVEL MANAGED OBJECT CONFIGURATION CALLBACK (NEConfigCb) | AN NEConfigCb OBJECT MUST IMPLEMENT A deliverNEConfig() METHOD FOR NOTIFICATION OF NETWORK-ELEMENT LEVEL MANAGED OBJECT CONFIGURATION CHANGES. REFER TO THE SECTION ON NETWORK-ELEMENT LEVEL MANAGED OBJECTS FOR DETAILS ON THE FORMAT OF REPORTED NETWORK-ELEMENT LEVEL CONFIGURATION DATA. |
| EVENT NOTIFICATION CALLBACK (EventCb) | AN EventCb OBJECT MUST IMPLEMENT A deliverEvent() METHOD FOR EVENT NOTIFICATION. REFER TO THE SECTION ON THE EVENT DISTRIBUTOR FOR DETAILS ON THE FORMAT OF REPORTED EVENT DATA. |
| ACTIVE ALARM NOTIFICATION CALLBACK (AlarmCb) | AN AlarmCb OBJECT MUST IMPLEMENT A deliverAlarm() METHOD FOR NOTIFICATION OF ACTIVE ALARM CHANGES. REFER TO THE SECTION ON ALARM MANAGER FOR DETAILS ON THE FORMAT OF REPORTED ALARM DATA. |

FIG. 5

| ASN.1 PRIMITIVE AND APPLICATION TYPES SUPPORTED BY SMI-PV2 | | | |
|--|---------------------------|-------------------------|-------------------------|
| EMAP TYPE | ASN.1 TAG OR RFC1156 TYPE | IDL REPRESENTATION | IDL REPRESENTATION |
| ASN1BOOLEAN | BOOLEAN | BOOLEAN | BOOLEAN |
| ASN1INTEGER | INTEGER | LONG | LONG |
| ASN1UNINTEGER | *NOT A TRUE ASN.1 TYPE | UNSIGNED LONG | UNSIGNED LONG |
| ASN1OCTET | OCTET STRING | SEQUENCE<OCTET> | SEQUENCE<OCTET> |
| ASN1TIMETICKS | TIMETICKS | UNSIGNED LONG | UNSIGNED LONG |
| ASN1GAUGE | GAUGE | UNSIGNED LONG | UNSIGNED LONG |
| ASN1COUNTER | COUNTER | UNSIGNED LONG | UNSIGNED LONG |
| ASN1IPADDRESS | IPADDRESS | OCTET(4) | OCTET(4) |
| ASN1NULL | NULL | OCTET | OCTET |
| ASN1OLD | OBJECT IDENTIFIER | SEQUENCE<UNSIGNED LONG> | SEQUENCE<UNSIGNED LONG> |

| EMAP-SPECIFIC TYPES | | | |
|---------------------|--|--------------------|--------------------|
| EMAP TYPE | DESCRIPTION | IDL REPRESENTATION | IDL REPRESENTATION |
| LOGICALID | NETWORK ELEMENT OR MAINTENANCE UNIT LOGICAL IDENTIFIER | ASN1INTEGER | ASN1INTEGER |
| CLASSCODE | INTEGER VALUE WHICH UNIQUELY IDENTIFIES MANAGED OBJECT CLASS | LONG | LONG |
| INSTID | INTEGER VALUE WHICH UNIQUELY IDENTIFIES AN INSTANCE OF A GIVEN MANAGED OBJECT | UNSIGNED LONG | UNSIGNED LONG |
| ATTRCODE | INTEGER VALUE WHICH UNIQUELY IDENTIFIES AN ATTRIBUTE OF A GIVEN MANAGED OBJECT | LONG | LONG |
| CMDSEQNO | COMMAND SEQUENCE NUMBER | LONG | LONG |

FIG. 6

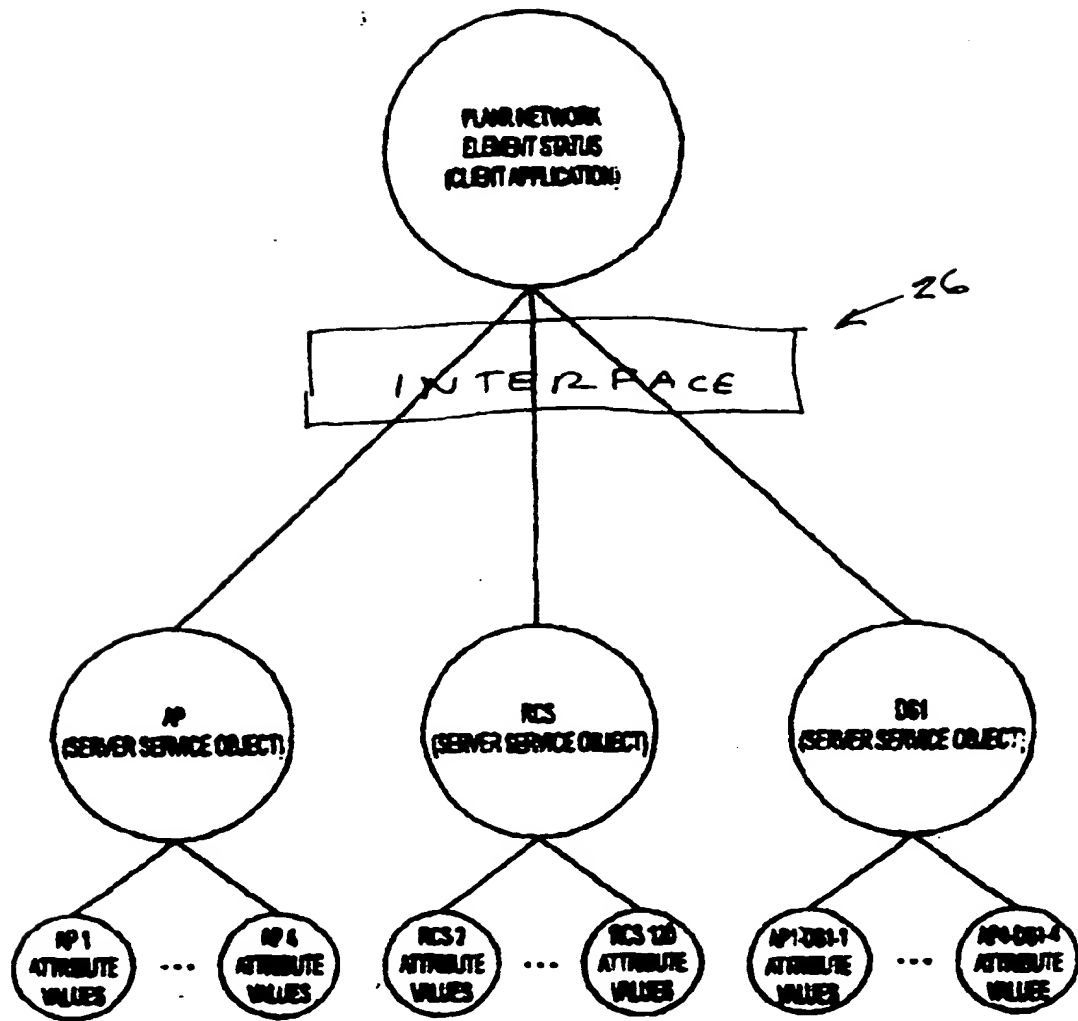


FIG.7

| EVENT CATEGORY | VALID CRITERIA | | | | |
|------------------------|-----------------------|-----------------------------------|------------------------|------------------------------------|---------------|
| | NETWORK ELEMENT ID | NETWORK ELEMENT ALARM LEVEL | MAINTENANCE UNIT ID | MAINTENANCE UNIT ALARM LEVEL | COMMAND ID |
| ALARM CLEAR | X | X | X | X | |
| ALARM SET | X | X | X | X | |
| COMMAND ACKNOWLEDGMENT | X | | | | X |
| COMMAND RESPONSE | X | | | | X |
| CONFIGURATION CHANGE | X | | X | | |
| INFORMATIONAL MESSAGE | X | | X | | |
| INITIALIZATION | X | | | | |
| STATE CHANGE | X | | X | | |
| ANY CATEGORY | X | X | X | X | X |

FIG. 8

| Macros | Meaning |
|---------------------------|--|
| EM_INVALID_USER | The user login identifier is invalid. |
| EM_UNKNOWN_HOST | The specified host is unknown. |
| EM_TOO_MANY_USER_SESSIONS | Too many client sessions are already active. |
| EM_TOO_MANY_APPLICATIONS | Too many client applications are already active for the specified login-host combination. |
| EM_INVALID_SESSION_ID | The specified client session id is invalid or no longer known. |
| EM_INVALID_APP_ID | The specified client application id is invalid or no longer known. |
| EM_INVALID_INST_ID | The specified instance id is invalid (e.g. NullInstance is specified but not accepted in the current application context). |
| EM_INVALID_NE_ID | The specified network element instance id is invalid or no longer known. |
| EM_INVALID_MO_ID | The specified managed object instance id is invalid or no longer known. |
| EM_INVALID_ATTR_CODE | The specified attribute code is not defined for the target managed object. |
| EM_NO_MATCHING_INST | No managed object instance contains a matching key list. |
| EM_INVALID_FILTER | The specified filter for either an event or alarm contained one or more invalid criteria. |
| EM_INVALID_FILTER_ID | The specified filter id for either an event or alarm is invalid or no longer known. |
| EM_NE_ISOLATED | The specified network element instance is isolated. |
| EM_INTERNAL_ERROR | The request could not be satisfied because of an EMS Server error. |
| EM_INVALID_OPERATION | An invalid operation was attempted. |
| EM_ACCESS_DENIED | Access permission was not granted for the current operation request. |
| EM_VERSION_MISMATCH | Software version mismatch detected. |
| EM_LOST_RESOURCE | A critical resource has been lost since the last client application heartbeat (e.g. AlarmManager abnormally terminated). |
| EM_INVALID_KEY | An invalid key sequence was specified (e.g. wrong number of logical id's specified for a target managed object instance). |
| EM_INVALID_CATEGORY | An invalid event filter category was specified. |

Fig. 9



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 30 8205

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| Y | * abstract * | 3,7,8, 10,17,18 | |
| A | * figure 1 * | 5,6,9, 11-16, 19-30 | |
| | * column 2, line 43-66 * | | |
| | * column 36, line 23 - column 37, line 64 * | | |
| | * claims 1-3,7-9 * | | |
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| | * page 2, line 51 - page 3, line 29 * | | |
| | * figures 1-3 * | | |
| | * claims 1,4,5,7,8 * | | |
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| A | * abstract * | 1,2,4-6, 9,11-16, 19-30 | |
| | * paragraphs '0002!,'03.4!,'06.1! * | | |
| | * figures 2,4,5 * | | |
| | --- | | |
| | -/-- | | |
| The present search report has been drawn up for all claims | | | |
| Place of search THE HAGUE | | Date of completion of the search 7 February 2000 | Examiner Cichra, M |
| <p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document</p> | | | |

EPO FORM 1503 03/82 (P4/C01)



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 99 30 8205

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| The present search report has been drawn up for all claims | | | |
| Place of search THE HAGUE | | Date of completion of the search 7 February 2000 | Examiner Cichra, M |
| <p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document</p> | | | |

EPO FORM 1503 03.92 (P4/C31)

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07-02-2000

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EPO FORM P0459

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